# DESCRIPTION OF OPTIONAL MODULES

This document provides a brief content description of optional modules to help you to select your choices. **Please note, the modules listed here are not necessarily all available on your programme.** Please refer to your Programme Specification or Module Choice Form for information about the options available to you.

New modules (2024/25 versions) will not be shown on the Module Catalogue until early August. However, you can view the previous 2023/24 versions of the Module Specifications at:
https://lucas.lboro.ac.uk/epublic/wp5016.main?dept=TT&dept2=TT

## Part C

**Semester 1**

| **Module Title:** Spacecraft Engineering<br><br>**AERO ONLY** | **Module Code:** 24TTC012<br>**Module Leader:** Dr Christopher Harvey | **Pre-requisites:** None<br>**CW/Exam split:** 100% Exam |
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| **Aims:**<br>The aim of this module is to present the key elements of spacecraft design, by considering each of the main sub-systems that contribute to fulfilling the particular mission objectives.<br>**Contents:**<br>Spacecraft sub-systems; the spacecraft environment; design methodology; spacecraft propulsion; launch vehicles; spacecraft dynamics; orbital motion and mission analysis; attitude control systems; power systems; spacecraft structures and mechanisms; thermal management; communications. | | |

| **Module Title:** Noise Control<br><br>**AERO/AUTO** | **Module Code:** 24TTC040<br>**Module Leader:** Dr Dan O'Boy | **Pre-requisites:** TTB002<br>**CW/Exam split:** 30% CW, 70% Exam |
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| **Aims:**<br>The aim of this module is for the student to understand the fundamentals of acoustics and the application to the design of noise control and mitigation in vehicles, with particular application to the luxury market and growth markets, taking into account sustainable design of communities, legal aspects and planning.<br>**Contents:**<br>Basic Concepts, Acoustics and the link to fluids, solution to the 1D wave equation, sound pressure level, sound power level, Community noise, the role of the planning system, legal restrictions and conformity, Sound in Enclosures, Examples of pipe acoustics in jet engine fuel pipes, simplified low order modelling of gas turbine acoustics, simulation led design, Sound Transmission in Ducts, thermo-acoustics, Sound Transmission in Partitions, resonator led design, Sound Absorption Mechanisms, Noise sources in automotive and aeronautical technology, future noise source trends, vehicle body in white design for NVH, experimental measurement methods and examples of the use of Matlab to understand turbine engine startup, Formula 1 race car design, quarter wavelength resonators and metamaterials, active noise cancellation, legislative trends in influencing commercial design for society. Conflicting trends of external soundscape against internal functional performance. | | |

| **Module Title:** Gas Turbine Design 1<br><br>**AERO ONLY** | **Module Code:** 24TTC050<br>**Module Leader:** Prof Duncan Walker | **Pre-requisites:** TTB203<br>**CW/Exam split:** 100% CW |
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| **Aims:**<br>The aim of this module is for the student to understand the physical laws and engineering considerations which influence the aerothermal design and performance of aircraft gas turbines.<br>**Contents:**<br>Thermodynamic cycle calculations to satisfy performance requirements/criteria. | | |

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| Engine sizing analysis.<br>Compressor and turbine stage design.<br>Compressor and turbine velocity triangle design.<br>A basic introduction to combustors.<br>Off-design performance of gas turbine engines. |

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| **Module Title:** **Stress and Structural Analysis**<br>**AERO/AUTO** | **Module Code:** 24TTC053<br>**Module Leader:** Dr Simon Wang | **Pre-requisites:** TTB204<br>**CW/Exam split:** 100% Exam |
| **Aims:**<br>The aim of this module is for the student to build on the theories of structural analysis in TTB204 to cover general static stress analysis for elastic continuum with emphasis on two-dimensional thin plate structures.<br>**Contents:**<br>Stress/strain states, deformation law, constitutive law, plane stress/strain problem, displacement/stress solution method, principal stresses and failure criteria, thin plate analysis. | | |

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| **Module Title:** **Introduction to Computational Fluid Dynamics**<br>**AERO/AUTO** | **Module Code:** 24TTC102<br>**Module Leader:** Dr Andrew Garmory | **Pre-requisites:** None<br>**CW/Exam split:** 50% CW, 50% Exam |
| **Aims:**<br>The aim of this module is for students to understand the fundamental principles of CFD and to learn the basic methodologies incorporated in modern commercial CFD packages.<br>**Contents:**<br>Governing Equations, Solution of Discretised Equations, Introduction to Turbulence and Turbulence Modelling, Pressure-Correction Methods, Boundary Condition Selection. | | |

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| **Module Title:** **Sensor Fusion for Intelligent Vehicles**<br>**AERO/AUTO** | **Module Code:** 24TTC103<br>**Module Leader:** Dr Jingjing Jiang | **Pre-requisites:** TTB202<br>**Other pre-requisites:** Basic coding skills, including Matlab<br>**CW/Exam split:** 40% CW, 60% Exam |
| **Aims:**<br>The aim of this module is for the students to understand the fundamentals of sensor fusion and their applications to aeronautical and automotive engineering problems.<br>**Contents:**<br>Overview of sensors in automotive and aeronautical systems.<br>Probability and basic statistics for multi sensor systems.<br>Linear estimation, dynamic systems and Kalman filter.<br>System implementation and integration: digital implementation, multiple sensor integration and architecture. | | |

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| **Module Title:** **Vehicle Dynamics and Simulation**<br>**AUTO ONLY** | **Module Code:** 24TTC066<br>**Module Leader:** Dr Yuanjian Zhang | **Pre-requisites:** TTB002<br>**CW/Exam split:** 100% CW |
| **Aims:**<br>The aim of this module is for the student to understand the principles of vehicle dynamics and approaches to approximate the vehicle performance in longitudinal and vertical directions, assisted by digital twin technique and simulation tools. Further aims to consolidate earlier fundamental learning about dynamics, systems, and signals, to investigate the key factors that determine the vehicle dynamics and prepare basic knowledge and abilities (modelling, simulation, and optimization) for further study. An experience of vehicle testing and virtual racing competition, and associated data analysis will enhance the knowledge understanding. The application of digital twin technique will also enlighten students on new methods and tools for future vehicle design.<br>**Contents:**<br>Principles of vehicle dynamics: Vehicle drivability (traction and braking). Vehicle drivetrain design. Vehicle ride comfort. Vehicle powertrain components. Mathematical models for vehicle dynamics. Tools: Simulation tool (Matlab/ Simulation). Digital twin. Real experiment tools (data collection). Parameter Optimization Method and | | |

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| Software. Methods: Theoretical analysis. Mathematical modelling. Software based Simulation. Digital Twin based Simulation. Real Vehicle Test. |

## Part C

**Semester 2**

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| **Module Title:** **Aircraft Design**<br><br>**AERO ONLY** | **Module Code:** 24TTC010<br>**Module Leader:** Dr Bjorn Cleton | **Pre-requisites:** TTB109, TTB209<br>**CW/Exam split:** 100% CW |
| **Aims:**<br>The aim of this module is to take a simplified aircraft customer requirements document and to consider multiple disciplines in order to achieve a conceptual design.<br>**Contents:**<br>Customer requirements. Certification and airworthiness. Aircraft configuration. Analysis of aircraft data to generate initial parameter estimates. Performance constraints to determine wing loading and thrust to weight. Mission sizing to determine maximum take off weight. Aircraft layout to create an engineering drawing and a 3D CAD model. Environmental factors. Aircraft cost. | | |

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| **Module Title:** **Gas Turbine Design 2**<br><br>**AERO ONLY** | **Module Code:** 24TTC011<br>**Module Leader:** Prof Duncan Walker | **Pre-requisites:** TTB203, TTC050<br>**CW/Exam split:** 100% CW |
| **Aims:**<br>The aim of this module is for the student to understand the processes involved in mechanical aspects of gas turbine design.<br>**Contents:**<br>Engine Cycle Calculations, Turbomachinery, Blade Cooling, Combustion Systems, Preliminary Design of Components, Detailed Aerodynamic and Mechanical Design of Components, Overall Mechanical Considerations. | | |

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| **Module Title:** **Aerodynamics**<br><br>**AERO ONLY** | **Module Code:** 24TTC051<br>**Module Leader:** Dr Andrew Garmory | **Pre-requisites:** TTB101, TTB201<br>**CW/Exam split:** 20% CW, 80% Exam |
| **Aims:**<br>The aim of this module is for the student to understand the general and fundamental theory of 3-D viscous compressible flow, to learn the basic approach to viscous inviscid interaction methods based on coupling of a panel method and a boundary layer analysis, and to become aware of some practical issues related to experimental and applied aerodynamics.<br>**Contents:**<br>Equations governing viscous flow: 3D Navier-Stokes and energy equations for compressible/incompressible flow, non-dimensional forms (Reynolds/Mach numbers), and foundations of Computational Aerodynamics.<br>Boundary layer analysis: 2D and 3D, laminar and turbulent, integral methods and pde methods, transition prediction (en method), simple turbulence modelling, separation on aerofoils including leading edge/trailing edge stall.<br>Inviscid incompressible aerodynamics prediction methods: Euler equations and pde approach, source panel methods, vortex panel methods for lifting bodies, 2D and 3D implementation.<br>Viscous-Inviscid Solution Coupling<br>Experimental methods: wind tunnel types and instrumentation.<br>Drag mechanisms: overview, skin friction, form drag & wave drag.<br>High lift systems.<br>Flow control methods. | | |

| Module Title: Flight Control Systems<br><br>**AERO ONLY** | **Module Code:** 24TTC057<br>**Module Leader:** Dr Matthew Coombes | **Pre-requisites:** MAB104, TTB202, TTB209, TTC067<br>**CW/Exam split:** 100% Exam |
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**Aims:**
The aim of this module is for the student to understand the analysis, design and implementation of flight control systems.
**Contents:**
Equations of motion. Aircraft response to controls. Transfer functions; state-space models. Basic longitudinal and lateral modes.
Flight control systems; stability augmentation systems; simple autopilot functions. Classic and modern flight control design methods.
Handling qualities, fly-by-wire.

| Module Title: Finite Element Methods<br><br>**AERO/AUTO** | **Module Code:** 24TTC002<br>**Module Leader:** Dr Christopher Harvey | **Pre-requisites:** TTB204<br>**CW/Exam split:** 40% CW, 60% Exam |
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**Aims:**
To learn how to derive and employ finite element methods to solve stress-strain, steady-state heat flow and vibrational problems.
To implement these methods computationally using Matlab to allow for static analysis of automotive and aerospace structures
To introduce the use of the FEM commercial software, MSC Nastran and Patran.
**Contents:**
Direct stiffness formulation;
Standard and modified Galerkin methods;
Galerkin formulation of extension, bending and torsion 1D finite elements;
Extension of these ideas to plane and space truss analysis, and plane and space frame analysis;
Galerkin formulation of stress-strain and steady-state heat flow problems in 2D using triangular and quadrilateral elements;
Introduction to mass matrices and free undamped vibration analysis to find natural frequencies and mode shapes;
Introduction to the Galerkin formulation derivation of stress-strain in 3D using tetrahedral elements.

| Module Title: Principles of Composite Materials & Structures<br>**AERO/AUTO** | **Module Code:** 24TTC054<br>**Module Leader:** Dr Gang Zhou | **Pre-requisites:** TTA104, TTB204<br>**CW/Exam split:** 100% Exam |
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**Aims:**
The aim of this module is for the student to understand basic concepts, fundamental principles and some important issues encountered in the analysis and design of advanced fibre-reinforced composite structures.
**Contents:**
Basic concepts and overview, composite constituent properties, laminae properties, lamina failure criteria, rules of mixtures, laminate theory, laminate mechanical characteristics, laminate design, thin-walled sections properties, damage mechanisms, stress and failure analysis of laminated structures, production processes, composite sandwich structures, mechanical behaviour in uniaxial loadings, applications of composite structures in aerospace and automotive industries.

| Module Title: Machine Intelligence<br><br>**AERO/AUTO** | **Module Code:** 24TTC201<br>**Module Leader:** Dr Miguel Martinez Garcia | **Pre-requisites:** None<br>**CW/Exam split:** 20% CW, 80% Exam |
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**Aims:**
The aims of this module are to:
- understand the fundamental and principles of machine intelligence.
- understand their applications to aeronautical and automotive engineering problems.
**Contents:**
- Introduction to artificial intelligence & machine learning

- Basic formulation of classification, clustering and regression problems
- Probabilistic ML methods: probability, distributions & Bayesian inference, etc.
- Artificial neural networks: backpropagation & supervised learning, etc.
- Evolutionary computation: genetic algorithms, etc.
- An overview of advanced AI topics: deep learning & hybrid intelligence, etc.
- Introduction to AI related engineering applications: monitoring & optimisation, etc.

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| **Module Title:** Battery Technology<br><br>**AERO/AUTO** | **Module Code:** 24TTC202<br>**Module Leader:** Dr Ashley Fly | **Pre-requisites:** TTB211<br>**CW/Exam split:** 100% Exam |

**Aims:**
The aims of this module are to:
- Enable the student to understand the principle theories and operation of electrified vehicle and aircraft powertrains with a focus on battery technology.
- Further aims are to understand the key developments in this field, establish knowledge in electrochemical processes and gain experience in the operation and performance analysis of batteries.

**Contents:**
Introduction to batteries and electrification of ground and air vehicles.
Fundamental electrochemistry and thermodynamics for batteries.
Different batteries and their suitability for aeronautical and automotive applications, with a focus on the lithium-ion battery.
The design, manufacturing and operation of batteries for different applications.
Operation of batteries in transport applications, including battery cell, module and pack design.
Battery degradation mechanisms, lifetime, safety and management systems.
Power electronics components required in an electric propulsion system.
Current limitations and research challenges in electrified vehicles for aeronautical and automotive applications.

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| **Module Title:** Crashworthiness<br><br>**AUTO ONLY** | **Module Code:** 24TTC068<br>**Module Leader:** Dr Simon Wang | **Pre-requisites:** None<br>**CW/Exam split:** 100% Exam |

**Aims:**
The aim of this module is for the students to understand the principles of vehicle crashworthiness design, in the context of human body protection and crash energy absorption through proper design of restraint systems and proper selection of material and structural forms. In addition, the students must be able to use the fundamentals in human body injuries and mechanism of impact energy management in some practical situations.

**Contents:**
Introduction to Crashworthiness The scale of the crash injury problem, why occupants are injured and the history of crashworthiness.
Human Anatomy How people break and how injury tolerance is measured.
Crashworthiness Assessment Worldwide crash safety regulations and consumer crash tests.
Restraints The role of restraint systems in occupant protection.
Structures The role played by the body shell in occupant protection.
The Real World Variations in real crash types and in occupant response to crash forces, implications for crashworthiness.
Static analysis of vehicle body structures: Energy methods will be introduced.
Plastic behaviour of materials: Fundamentals of plasticity of materials will be introduced.
Static/dynamic plastic collapse of beams: Basic mechanics of crash energy absorption will be introduced.